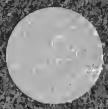

# HISTORY

OF THE

# SIGNAL SERVICE

WITH CATALOGUE OF

## PUBLICATIONS, INSTRUMENTS AND STATIONS.



PREPARED UNDER THE DIRECTION OF
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CHIEF SIGNAL OFFICER OF THE ARMY.

WASHINGTON CITY.
1884.

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# SIGNAL SERVICE, ARMY OF THE UNITED STATES.

The Signal Service of the Army of the United States, as at present constituted, is an organization upon which is devolved the two-fold duty (1) of providing for the Army an efficient corps charged with the work of opening and maintaining communication, at the front, in time of war, and (2) of noting the development and progress of storms and other meteorological phenomena and reporting the same to the public with predictions of probable future atmospheric conditions.

The field-telegraph trains of the Signal Service are organized for use with armies. They are managed by soldiers who are drilled to march with, manœuvre, work, and protect them. The train carries light or field-telegraph lines, which can be very quickly erected or run out at the rate of two or three miles per hour. They can be put in use for any distance, and be as rapidly taken down, repacked, and marched off with the detachment to be used elsewhere.

The Signal Service also transmits intelligence in reference to storms or approaching weather changes by the display of warning-signals, and by reports posted in the different cities and ports of the United States. Maps showing the state of the weather over the United States are exhibited at boards of trade, chambers of commerce, and other places of public resort. Bulletins of meteorological data for all the stations are also prominently displayed, and distributed, without expense, to the leading newspapers.

Signal stations are also established in connection with the life-saving stations. These stations are connected by telegraph, and the former, in addition to displaying storm-warning signals and making the usual meteorological reports, make special reports upon the temperature of the water, tempests at sea, the sea-swells, etc. They also summon assistance to vessels in distress, from the nearest life-saving stations, or from the nearest port.

Stations for river reports, to give notice of the conditions of the rivers affecting navigation and floods, are also established on the principal interior rivers and their tributaries.

## MILITARY ORGANIZATION.

An economic feature of the Weather Bureau is that it is a *military service*. All its observational work is done by officers and enlisted men of the Army, and all its official publications are prepared under authority, and with the regularity and dispatch to be had only under military discipline. The military relations of the Signal Service have been found by experience to give it great advantages in extending its network of stations over the sparsely populated territories of the country, from which many of the most indispensable meteorological reports are obtained. The observers of the Signal Corps are trained not only in the art and practice of military field-signalling, but in the ordinary army drill and rules and habits of discipline; they constitute a part of the regular military establishment of the nation, always ready for active service. Occupied in time of peace with scientific work of acknowledged value, the cost of their maintenance is but a small additional burden upon the country, fully requited by their meteorological services to it. Experience has shown that arduous meteorological labors such as they perform have not been secured from any civil corps. As the Signal Service observers must report several times a day to

the Washington office, each regular report serves in effect as a telegraphic roll-call of all the stations spread over the country from the Atlantic to the Pacific, and from the lakes to the Gulf of Mexico, insuring promptitude, vigilance, and steadiness in the entire Signal Corps.

The officers and men of the Signal Service are instructed for the different branches of the service at Fort Myer, (formerly Fort Whipple) Virginia, and at the central office in Washington City. They are taught signalling in all its branches, telegraphy, the use of the various meteorological instruments, the modes of observing, and the form and duties required at stations of observation; the force is also drilled with arms, with the field-telegraph train, the construction of permanent telegraph lines, and in the usual duties of soldiers. For the duties of the observation of storms and for the display of warning signals, all stations communicate directly with the central office in Washington, over telegraphic circuits arranged with the different telegraphic companies, and connecting with the office at fixed hours each day and night.

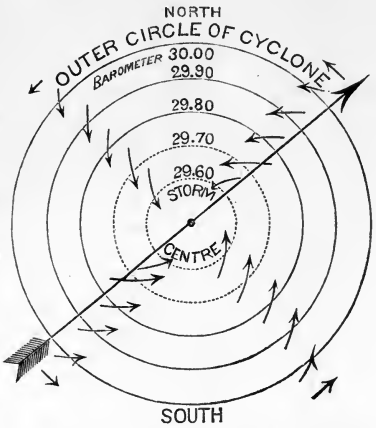
The net-work of the Signal-Service stations now extends over the continent from the Atlantic to the Pacific coasts, and the intervening territory from the Gulf (including the West Indies) to the Canadian frontier, and is in receipt, by comity of exchange, of daily telegraphic intelligence of the weather from the Canadian Dominion and its outlying posts. The office work is still in need of more stations in the interior of the country and the Northwest Territory of the Dominion of Canada; provision will ere long be made for supplying them, when the new transcontinental telegraph-line is extended from Manitoba to British Columbia. These reports from one hundred and forty-seven stations of observation are not unfrequently concentrated at the central office in the space of *forty minutes*. The stations at which cautionary signals are displayed are equipped with flags, lanterns, &c., for exhibiting the cautionary day or night signals, and also for communicating with vessels of any nationality.

The meteorological division of the United States Signal Service was established in 1870, and was an additional duty imposed upon it. The progress of modern inquiry into the changes taking place in the weather, and especially into the phenomena of storms, had for many years previous strengthened the conviction that they are not capricious, but follow certain laws. To provide, therefore, for taking meteorological observations, with a view to "giving notice by telegraph and signals of the approach and force of storms," was the end originally contemplated by the joint resolution of Congress, which passed February 9th, 1870, authorizing the Secretary of War to carry this scheme into effect. The organization of a meteorological bureau adequate to the investigation of American storms, and to their pre-announcement along the northern lakes and the sea-coast, was, under the auspices of the War Department, immediately intrusted to the Chief Signal Officer of the Army, Brigadier-General Albert J. Myer; and the division thus created in his office was designated as the "Division of Telegrams and Reports for the Benefit of Commerce."

This was the first legislation of the United States Government inaugurating a national weather service. The peculiar geographical extension of the country, stretching over fifty-seven degrees of longitude and twenty-two of latitude, afforded exceptional advantages for investigating and predicting the storms which cross its broad area; for experience and observation had shown that they generally move from west to east, and not unfrequently along the meridians. But the vast extent of the storm-field, coupled with the fact that the "law of storms," was then but roughly outlined, made the execution of this task a very difficult and tedious work calling for great caution and the most accurate observations. Espy, Redfield, Loomis and Ferrel, in the United States, as well as many distinguished meteorologists

abroad, had investigated the general laws of storms, but their demonstration on the wide continental field of America, as well as the discovery of many details affecting their practical application to weather prediction, awaited further, more extensive, and more exact research.

*Early developments.*—At first the number of stations and the area covered by the predictions were limited. But, when once the fact had been established that at any hour of the day or night, the central office could almost instantly call for reports from all parts of the country, and receive them from all its stations, taken at the same moment of time, and revealing the actual status of the atmosphere over its whole field of inquiry, the sense of security in its scientific processes, and the confidence that the results were built upon "the solid ground of nature," gave it a powerful foward impulse.




Horizontal movements of air around centre of cyclone in northern hemisphere. Large arrow shows path of storm: smaller arrows show the course of the winds increasing in velocity as they approach the centre.

The method of simultaneous reports, it was felt, was a sure road to the desired goal. In a short time additional stations were established within the United States, making sixty-six in all. A comparison of the tri-daily forecasts, or "probabilities," as they were styled, with the weather-conditions following and reported as actually observed as far as verified, from November 1, 1871, to October 1, 1872, gave an average of verification of 76.8 per cent.; and during the year ending June 30, 1872, 354 cautionary signals were issued, with an estimated percentage of correctness amounting to 70. These results also afforded the most complete demonstration of the laws of storms and the movement of cyclones that had ever been obtained in any country.

By act of Congress, approved June 10, 1872, the Signal Service was charged with the duty of providing such stations, signals, and reports as might be found necessary for extending its research in the interest of *agriculture*. The agricultural societies over the land earnestly entered into and co-operated with the service in this new develpment of its inquiries and reports. Eighty-one such societies, thirty-eight boards of trade or chambers of commerce, numerous scientific institutions, colleges, and leading professional men put themselves in communication with the Chief Signal Officer, with a view to facilitate this branch of this work. The scientific societies at home and abroad began to take the liveliest interest in the general labors of the service, and to express the highest approval of the results attained. And, beyond the limits of the United States, numerous marine observations, which General Myer had previously desired, with the purpose of studying the atmosphere as a unit both on the ocean and the land, were forwarded regularly to the central office.

The expansion of the work, in 1873, under the stimulus of a world-wide favorable notice, was even more rapid than in the previous year. On March 3d, Congress authorized the establishment of Signal Service stations at the light-house and life-saving stations on the lakes and sea-coast, and made provision for connecting the same with telegraph-lines or cables "to be constructed, maintained, and worked under the direction of the Chief Signal Officer of the Army, or the Secretary of War, and the Secretary of the Treasury." Early in this year the office also began the regular publication of a "Monthly Weather Review," summarizing in a popular way all its data and showing the results of its investigations, as well as presenting

these in graphic weather-charts adapted to the comprehension of communities it was destined to reach. The library of the signal office was increased to some 2,500 volumes bearing on the special scientific duties imposed upon it. The tests of meteorological instruments previously instituted enabled it to greatly improve and simplify its instrumental apparatus. The percentage of verification of its predicdictions for the year ending June 30, 1873, was, for each geographical division, as follows:

| | |
|---|---|
| New England | 81.50 |
| Middle states | 81.17 |
| South Atlantic | 79.92 |
| Lower lakes | 78.90 |
| Upper lakes | 75.25 |
| Eastern Gulf | 77.16 |
| Western Gulf | 74.40 |
| Northwest | 74.00 |

It was in September of this year also that, at the proposal of the Chief Signal Officer to the International Congress of Meteorologists, convened at Vienna, the system of world-wide co-operative simultaneous weather observations, since then so extensively developed, was inaugurated, and began to contribute its data to the signal office records. Thus, in his report for 1873, the Chief Signal Officer was able to say of the simultaneous international observations: "Their utility is no longer questioned, and effort at home and abroad turns only toward their development." The service was now no longer an experiment, but an assured success.

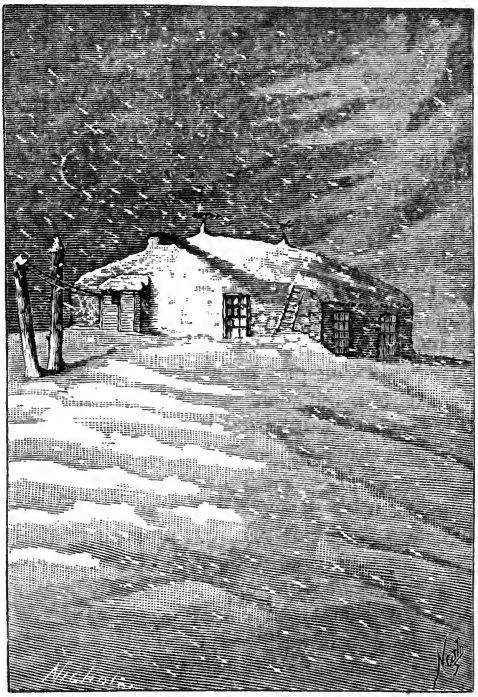
In addition to the regular force of military observers, there was transferred to the Signal Service on February 2, 1874, at the instance of Professor Joseph Henry, Secretary of the Smithsonian Institution, the entire body of Smithsonian weather observers in all parts of the United States. This voluntary civilian force continues to the present day to contribute its scientific labors in behalf of the Signal Service researches in the domain of continental meteorology and climatology. The voluntary observers, thus co-operating with General Myer, with others who have embarked in the work since 1874, now number three hundred. Since June 19, 1874, the reports from the Army post surgeons have been ordered by the Surgeon General, United States Army, to be sent to the Chief Signal Officer. At present they number forty-nine. Many of them have acquired great exactness and experience in instrumental observations, and noting and recording physical phenomena, so that their monthly reports to the Chief Signal Officer alone make a rich repository of American climatology. This voluntary corps is receiving constant additions, and inducements are held out by the service to competent civilians, especially in the sparsely settled and frontier districts, to join in its investigations.

### SIMULTANEOUS WEATHER OBSERVATIONS.

In organizing this service the first problem that presented itself was to devise a system of observations which would, when mapped accurately, represent the aerial phenomena at the same instant of time, and in their *actual* relations to each other, and thus enable the investigator to discover the laws of storms and their rates of movement over the earth's surface. "The history of science," says one of its foremost representatives, "proves that unconnected, unsystematic, inaccurate observations are worth nothing." Certainly in the domain of meteorology, no solid foundation for the science of the weather could have been laid in 1870 upon any of the then existing observational systems. The European weather stations, at that date, and long after, were engaged in making non-simultaneous reports; no two of them, unless they happened to be on the same meridian, read off their instruments at the same time.

The perfectly simple scheme of simultaneous observations aimed at the rescue of weather research from the chaos in which for ages it had lain. Its cardinal principle of observation is to gain frequent views of the atmospheric condition and movements over the country as they *actually* are, and as they would be seen, could they, so to speak, be photographed. In no other way can the bearings of the various storm-winds and their connected phenomena be detected, or the rates of their transition determined. All the predictions of the signal office, therefore, have from its beginning until now, been from reports taken simultaneously.

*Current daily work*,—The operations of the meteorological division of the Signal Service, popularly known as the "Weather Bureau," have been, every year since its creation, somewhat enlarged by Congress, until they have become numerous and varied. The first to be specially mentioned is the daily work of weather prediction, including storm warnings. These are issued from the Office of the Chief Signal Officer three times every day, under the titles of "Indications" and "Cautionary Signals," and are based upon three series of simultaneous weather reports telegraphed to Washington from all parts of the United States and Canada; also at intermediate hours if necessary, based upon special reports, The tri-daily telegraphic observations are taken simultaneously at all stations at 7.00 a. m., 3.00 p. m., and 11.00 p. m., Washington time, and at once put upon the wires; those taken at 11.00 a. m. and 7.00 p. m., Washington time, are not telegraphed unless specially called for. The number of stations from which tri-daily telegraphic reports are received at the central office is 147. This number includes 12 stations belonging to the weather service of the Dominion of Canada, which, by comity of exchange, send daily reports to the Chief Signal Officer. The total number from which such reports are received daily is 157; but, including those sent by mail it is 202; while the total of reporting stations within the United States territory, including the special printing, display, special river, cotton-region and sunset stations, on the 30th of June, 1884, was 464. The vertical range of the observations extends from sea-level to the summits of Mount Washington (6,286 feet) and Pike's Peak (14,151 feet). The observations include the readings of the barometer and dry-bulb and wet-bulb thermometers; the direction and velocity of the wind; the amount of rain or snow fallen since last report; the kind, amount, velocity and direction of movement of clouds; auroras, haze, fog, smokiness, frost, etc., and to these data the river stations add the readings of the river-gauge, and the sea-coast stations the direction and character of the ocean-swell. The maximum and minimum temperatures in the past twenty-four hours are also given.



Signal Service station on the summit of Mount Washington.

Having taken their instrumental and other observations at either of the hours

specified, the observers prepare their reports in *cipher*, by which expense for the telegrams and time in their transmission are saved, as well as greater accuracy secured.

These cipher telegrams condensed by means of the cipher code in five to ten words for each report, as soon as received in the Washington office, are translated from cipher and entered on the bulletin blanks and at the same time in their proper places on the weather maps. This is done under the supervision of the assistant charged with the preparation of the weather predictions and the announcement of the storm-warnings.

It was not until November 4, 1870, that the Chief Signal Officer was able to issue weather bulletins. On that day, at twenty-four stations in the United States systematized *simultaneous* observations of the weather by trained Signal Service observers were first taken and telegraphed to the central office at Washington. The same day the bulletins made up from these reports were prepared and telegraphed by the Chief Signal Officer to more than twenty cities. The first storm-warning was bulletined along the lakes a week later, for the benefit of the large commercial and marine interests exposed to the furious gales which sweep especially in autumn, over their waters. These tentative attempts to introduce the novel system of practical weather telegraphy were vigorously followed up, and the success realized so early in the operations of the service was as gratifying to the public as to the office itself. This success was due in a large measure to the system of observation and reports being in the strictest sense *simultaneous*.

## WEATHER-MAPS.

To arrive at any result it was necessary to chart weather maps from the reports thus received by telegraph. The Signal Service tri-daily weather-map is a map of the United States on which all the Signal Service stations are entered in their appropriate geographical places, and having annexed to each station the figures expressing the readings of the barometer and thermometer, the velocity of the wind the amount of rainfall within the previous eight hours, &c.; and also symbols indicating the direction of the wind, and the form and amount of cloud, at the given time of observation. The observations taken at each station are all put down on the map, and the relations between them are thus made sensible to the eye of the signal officer, by the figures and symbols, and also by lines drawn to group the geographical areas over which like conditions prevail. The weather map is, therefore, to the meteorologist, an indispensable means of obtaining a survey, and prosecuting a careful and connected study of the phenomena he seeks to understand.

On page 15 will be found a *telegraphic* weather map, which illustrates the method of representing, graphically, the atmospheric conditions over the entire country.

The tri-daily weather map, prepared for use at the central offices, resembles this, in general, but is very much larger and contains more data.

*Synoptic Weather-Map.*—By preparing a graphic weather-map embodying the telegraphic data furnished to the Chief Signal Officer every eight hours in the day, the officer charged with formulating the storm predictions, gains and retains a clear idea and mental image of the atmosphere. A great soldier has said: "There is nothing ideal in war," and it may be said with equal force, there is no work which for its intelligent execution demands greater precision of method, more copious and circumstantial details, and closer attention to the developments of the hour, than weather forecasting over a continent. The weather-map brings all these minutiæ within view, and makes the meteorologist master of the whole mass of observations, as hours consumed in the study of numerical data could not do. Every weather-map is therefore, a *generalization* in itself, as well as record of the data. A series of

weather maps is a history of the ebb and flow, the fluctuations and tossings of the aerial ocean, and of the more subtile yet influential processes concerned in producing the weather and determining the climate of the country.

PREPARATION OF THE "SYNOPSIS AND INDICATIONS" AND "SPECIAL BULLETINS."

From reading in the morning newspapers the "Synopsis and Indications" for the day, no one not initiated in the method of preparing them would suspect the magnitude of the work involved in their preparation. The study pre-requisite for each of the tri-daily press reports issued includes the draughting of seven graphic charts, exhibiting the data furnished by the simultaneous reports telegraphed from all the stations. These charts are: (*a*) A chart of barometric pressures, temperature, winds (direction and velocity), state of the weather, and the kind and amount of precipitation at each station. The isobars, (or line connecting stations where the barometric pressure, reduced to sea-level, is the same) are then drawn for every tenth of an inch, as also are isothermal lines for every 10° of temperature; while wind-directions are marked by arrows and their hourly velocities by numbers. (*b*) A chart of dew-points at all stations. There is also entered for each station the depression of the dew-point below the temperature of the air. On this are traced lines showing each five degrees of equal depression of the dew-point. A line is also drawn to show the dew-point of 32° Fahr. (*c*) A chart of the various cloud-conditions prevailing at the time over the United States, with the "weather" at each station, depicted by symbols; also once daily, the minimum and maximum temperatures. The cloud-areas—each form of cloud represented by a different symbol—are outlined and each one is distinguished. The appearance of the western sky at each station, as observed at sunset, which affords a strong indication of the weather to be anticipated for the next twenty-four hours, is also marked on this chart. (*d*) A chart of the *normal* barometric pressures, and of variation of the actual (corrected for temperaiure and instrumental error) from the normal pressures. The deviation or "departures" of the actual pressures from those which generally prevail are entered and exhibited on the map by appropriate lines. (*e*) A chart of actual changes of pressure occurring, showing separately the fluctuations of the atmosphere during the previous eight and twenty-four hours. (*f*) A chart of normal temperatures and of variations of the actual temperatures from the normal temperatures. The deviations or "departures" of the actual temperatures from those which generally prevail are entered and exhibited on the map by appropriate lines. (*g*) A chart of actual changes of temperature in previous eight and twenty-four hours. All these charts, each covering the whole of the country, must be made out, and the mass of data they embody sifted and analyzed, preliminary to the preparation of every one of the tri-daily bulletins issued from the central office. The charts have all to be draughted in about an hour or an hour and a half; but they are inter-corrective, each chart serving as a check on the others.

Armed with this charted material, the officer preparing the predictions proceeds first to compile the "Synopsis," and then to deduce the "Indications," and issue the necessary storm warnings, The "Synopsis" "Indications" and cautionary signals constitute the "Press-report" which, when finished, is telegraphed direct from the Office of the Chief Signal Officer to all parts of the country. The average time elapsing between the simultaneous reading of the instruments at the separate stations scattered over the United States, and the issue of the "Synopsis" and "Indications" based on these readings, has been calculated at one hour and forty minutes.

*Verifications of Predictions.*—An analysis of the predictions made for the year ending June 30, 1883, and a comparison with the weather conditions which actually occurred within the twenty-four hours next ensuing, give the following percentages of verifications:

Percentage of verifications for the year (forecasts of barometric pressures, temperatures, wind direction, and state of weather), 88.0.

Percentage of verifications for the year (forecasts of the state of the weather only), 89.8.

These percentages of accuracy refer to predictions of barometric, thermometric, wind-direction, and general weather changes. The average percentage of accuracy of the forecasts of the weather alone (including the state of the skies, whether clear, fair, or cloudy, and whether with or without rain) for all of the different districts is 89.8. The percentage for the Pacific coast region for "weather" only is 90.5. In other words, out of a hundred pre-announcements of the single element, "weather," for all parts of the country, ninety have been fulfilled by the event.

*Percentage of verifications for each month of the year ending June 30, 1883.*

| Districts. | 1882. | | | | | | 1883. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July. | August. | September. | October. | November. | December. | January. | February. | March. | April. | May. | June. |
| New England | 91.0 | 84.1 | 88.9 | 83.4 | 87.2 | 88.2 | 89.9 | 80.1 | 88.3 | 84.5 | 85.6 | 85.2 |
| Middle Atlantic states | 91.8 | 84.9 | 90.4 | 81.8 | 88.8 | 87.1 | 90.6 | 88.9 | 89.5 | 84.1 | 87.5 | 86.6 |
| South Atlantic states | 91.4 | 87.1 | 93.3 | 87.3 | 92.2 | 88.1 | 90.8 | 90.5 | 90.6 | 86.8 | 91.1 | 90.0 |
| Eastern Gulf states | 92.2 | 86.5 | 92.8 | 86.5 | 89.8 | 86.5 | 90.4 | 89.8 | 92.8 | 88.3 | 93.8 | 85.1 |
| Western Gulf states | 92.5 | 86.7 | 93.1 | 88.0 | 87.2 | 88.8 | 89.0 | 92.3 | 91.1 | 88.4 | 92.4 | 82.8 |
| Lower lake region | 91.1 | 86.9 | 88.6 | 86.3 | 89.8 | 89.6 | 89.5 | 89.3 | 90.9 | 84.4 | 89.5 | 81.5 |
| Upper lake region | 88.7 | 82.5 | 87.1 | 91.2 | 87.3 | 89.5 | 88.3 | 90.4 | 88.4 | 84.6 | 87.4 | 85.5 |
| Tennessee and Ohio valley | 90.7 | 84.9 | 91.7 | 85.1 | 90.1 | 87.9 | 89.8 | 91.3 | 91.4 | 85.5 | 90.7 | 86.0 |
| Upper Mississippi valley | 90.0 | 79.9 | 88.7 | 87.9 | 88.6 | 85.6 | 90.1 | 88.6 | 89.5 | 86.2 | 89.5 | 85.7 |
| Lower Missouri valley | 86.5 | 80.7 | 85.7 | 81.0 | 86.5 | 84.4 | 87.8 | 84.7 | 89.7 | 85.9 | 87.9 | 82.4 |
| Total | 90.6 | 84.4 | 90.0 | 85.8 | 88.7 | 87.6 | 89.6 | 88.6 | 90.2 | 85.9 | 89.5 | 85.1 |

*River Reports.*—The important work of observing and reporting the fluctuations and floods of the great western rivers was, at an early period of its history, undertaken by the Signal Service. Interstate commerce being necessarily much affected by the oscillations of the rivers, timely warnings of their rise and fall, and daily reports of the exact depth of water at numerous points, were eagerly asked for. These observations were found of so much importance that they have been extended over the western, southern, and California rivers, and deductions made from them, indicating impending changes, are daily published in the Washington weather reports. All measurements at each river station are made from the "bench-mark," as known to the river men of the vicinity, and the reading of the gauge is daily telegraphed to the central office, and all other interested stations. Knowing from such telegrams the height of the river at each station, as well as the total amount of reported rainfall higher up the river valley, the office is thus enabled to calculate and announce the time and degree of coming changes. Thus, timely premonitions of the great flood-waves that pass down the Mississippi, and also its fluctuations, are issued from this office.

The gauge used is very simple. In most cases it is a plank of pine or oak timber, two inches thick, ten inches wide, and long enough, when placed obliquely on the slope of the river bank, to cover the extreme low-water and high-water marks. When firmly imbedded in the earth, the "bench-mark," which is generally the lowest water known, is taken as the zero of the gauge, which is there carefully graduated, its subdivisions exactly corresponding to the vertical foot and subdivisions of

which they are intended to be indices. A "danger-line" is marked on the gauge, showing how far the water may rise, but no farther, without danger of a flood. The reports telegraphed to the press, showing how near each stream has risen to, or fallen below, the "danger-line," enable the public to predetermine dangerous inundations, and furnish steamboat-men and merchants the daily information requisite for intelligently directing the movements of their craft. During the flood-months the telegraphic river-reports are especially valuable to all river-shipping, and to all interested in the travelling and transportation facilities which depend upon it, as well as giving timely warnings of icè-floods or sudden rises and falls. The levee systems of the Mississippi and other great rivers are thus guarded, and the immense agricultural interests secured, as the flood-warning comes in time to summon the state force to strengthen the imperilled works. The value of this branch of the Signal Service work was amply shown during the floods in the Ohio valley in 1883 and 1884.

Daily bulletins of the river reports are regularly displayed at Augusta, Georgia; Bismarck, Dakota: Cairo, Illinois; Cincinnati, Ohio; Davenport and Dubuque, Iowa; La Crosse, Wisconsin; Fort Smith and Little Rock, Arkansas; Louisville, Kentucky; Memphis and Nashville, Tennessee; New Orleans, Louisiana; Pittsburg, Pennsylvania; Sacramento, California; Shreveport, Louisiana; Saint Louis, Missouri; Vicksburg, Mississippi, and Yuma, Arizona. In addition there are 35 special river stations from which reports are received.

In connection with this service, surface and bottom-water temperatures at points upon the rivers, lakes, and sea-coasts are observed and reported for the United States Commissioner of Fish and Fisheries, with a view to ascertain the proper waters in which to plant the various food-fishes and furnish statistics desired for the development of the national system of pisciculture.

The service reports such changes of temperature as affect canal navigation during the winter months. During the months when the market rates and freight schedules are affected by the probabilities of the canals closing, and when these water ways are thronged with hundreds of laden barges, the daily predictions indicate the thermometric conditions likely to ensue along their lines of transit. Such information protects the public from the imposition of excessive railway rates in the shipment of the grain crops, especially in an autumn season of protracted mildness, and effects a large saving to the mercantile world.

*Wide diffusion of the weather reports.*—The distribution of the tri-daily "Synopsis and Indications" over the whole country may be understood from the following official facts: The total number of these forecasts—1,095 issued every year—are telegraphed at the moment of issue to the principal cities, and are published in some form in almost every newspaper in the country. In many public and conspicuous places, they are also bulletined for popular inspection. In order that they may reach the farming populations, an arrangement is effected with the Post-Office Department by which special "Farmers' Bulletins" may be distributed at an early morning hour of each day, except Sunday, along the railroads radiating from the chief cities of the Union. These "Farmers' Bulletins" contain appropriate selections from the matter of the "midnight" report made up in the Washington office at 1 a. m. of each day, which, when it reaches the outlying stations by telegraph, is printed before daylight, and copies of it mailed to the rural postmasters for many miles around, and by them displayed in their offices. There are now eighteen cities at which the Signal Service observers reprint and circulate the telegraphic forecasts to 8,770 subcentres among the agricultural communities while the reports are yet fresh and timely. Each postmaster has the order of the Postmaster-General to display the report as soon as received in a frame furnished for the purpose, and to report in writing to the Chief Signal Officer the time of its receipt and display. The intelli-

gence of weather changes, with predictions and other data useful to the farmer in securing his crops or in other ways, on an average, reaches the different railway stations, hamlets, and villages throughout the United States in the forenoon. As the predictions cover twenty-four hours, and often hold good for twice that period, they therefore reach the denser rural populations twelve or fourteen hours before the period to which they apply expires, and not unfrequently a day and a half or more.

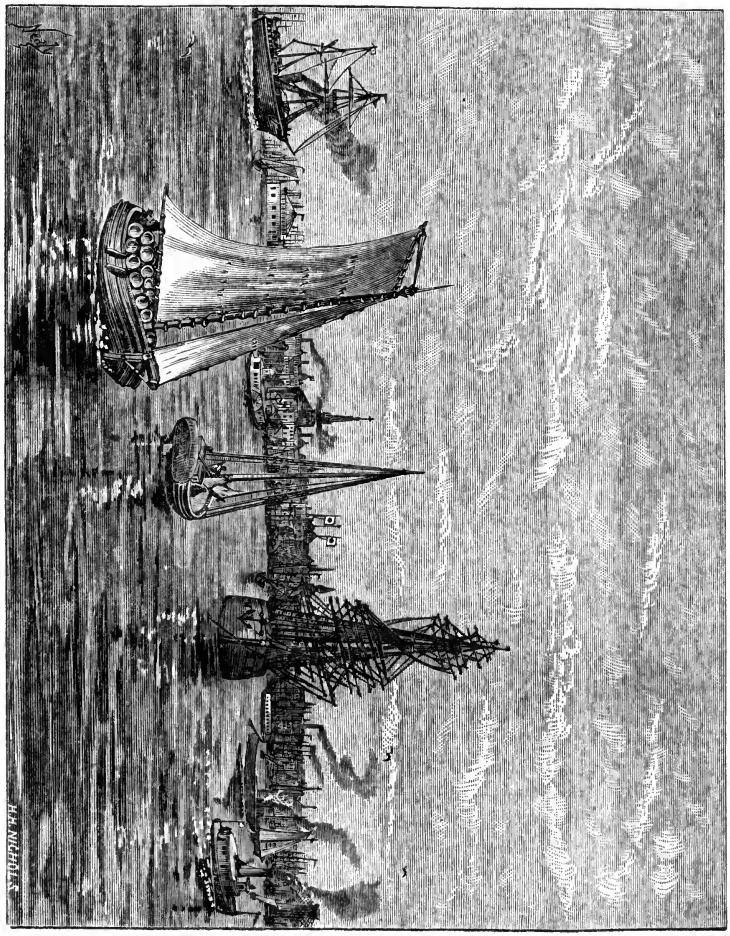
To make the reports more useful to the agricultural interests, the Chief Signal Officer has, by arrangement with the different railways, established a "Railway Weather-bulletin Service." In this work thirty-seven railway companies, distributing daily 1934 reports to as many railway stations, are now co-operating without expense to the government. The midnight report exhibiting the "Indications" is telegraphed to the railway companies, whose superintendents are charged with seeing that copies of it are bulletined and posted along their lines a few hours after it emanates from the Washington office. By this means the railroad officials and residents of districts which cannot otherwise be reached in time, secure the benefits of the government weather service. This system of distribution is in its infancy, but is capable of indefinite extension, and of diffusing the desired weather data to a large portion of the agricultural, commercial, and other interests of the country. The constant watch kept on the service, the confidence of the public in its work, and the value attached to its predictions and signals, are well illustrated by the complaints made when the forecasts are not fully justified.

*The cautionary storm-signals* which accompany the "Synopsis and Indications," issued to the press three times each day, constitute a very important part of the Signal Service work, and it was the possibility of preparing such storm-warnings for the benefit of navigation, that originally gave the chief stimulus to the establishment of a weather bureau. The United States has a double front with over 7,000 miles of sea-beaten coast, exclusive of the shore line of its great lakes ravaged by destructive tempests; and this vast stretch of marginal territory needs to be environed with stations from which observations can be taken, and premonitory intelligence of cyclone and anticyclone signalled by day and by night to storm-menaced shipping. If no other duty devolved upon the Service, this alone would more than justify its whole cost and warrant its extension. It is one of the most difficult and responsible tasks which can fall to the meteorologist, to put his science to the utmost stretch of accurate prevision, (and often it must be done with a very few minutes for deliberation) to decide at what points on the coast the storm-wind will strike with dangerous effect. It is, practically, fatal to the value of his warnings if they are found to be superfluous, since, in that case, they cease to command the attention of seamen. Nor, for like reason, must they be displayed too late; nor yet too early, lest they should interfere with the movements of vessels which might run out of the dangerous vicinity before the storm can reach them. Thus the perplexing questions which spring up at every display of the signals, lend to this part of the service intense interest. No such work had ever been undertaken in this country when the Signal Service was organized, and maritime storm-signalling in other countries had only been as yet rewarded by very moderate success.

On the organization of the United States weather service in 1870, General Myer began with great caution to prepare for this difficult and delicate part of his arduous task; and on the 24th of October, 1871, the display of signals on the sea-coasts and lakes commenced. The order regulating this display contemplated that the warning should be sent only to stations at which a wind having a velocity of twenty-five miles or more per hour would occur. As the anemometer at every station registers the wind's velocity for every hour, it is easy to ascertain whether any signal has been justified. Every such display is carefully followed up by the office, and the result—

"justified" or "not justified"—is recorded, as reported by the observers hoisting the signals by telegraphic order from the Chief Signal Officer.

The cautionary signals are of two kinds: 1. Those premonishing dangerous winds to blow from any direction. 2. Those premonishing off-shore winds, likely to drive vessels out to sea. Both kinds are needed by mariners as the storm-centres approach or depart from a maritime station. The first, distinctively termed the "Cautionary Signal," consists of a *red flag* with a *black square* in the centre, for warning in the daytime, and a *red light* by night. The second, or "Cautionary Off-Shore Signal," consists of a *white flag* with black square in the centre, shown above a red flag with square black centre by day, or a *white light* shown above a red light by night, indicating that, while the storm has not yet passed the station and dangerous winds may yet be felt there, they will probably be from a northerly or westerly direction; this second signal when displayed in the lake region in anticipation of high north to west winds is designated the "Cautionary Northwest Signal." The display of either signal, however, is always intended to be *cautionary*, and calls for great vigilance on the part of vessels within sight of it.



The cautionary signal flags as seen in New York harbor.

The Chief Signal Officer's report for the year ending June 30, 1883, states that, in that year, 1,557 such signals had been displayed in anticipation of dangerous

storms assailing the lake and sea coasts of the United States; and that of the number of "cautionary" signals displayed 83.9 per cent. were afterward reported as justified by dangerous winds; while of the number of "cautionary off-shore" signals displayed, 89.3 per cent. were afterward reported as justified. According to the rules of the office, a signal is set down as not justified unless it is shown after the display that winds exceeding twenty-five miles per hour in registered velocity have occurred at the display-station or within a radius of one hundred miles.

The total number of sea-ports and points on the lakes and sea-coasts where the storm-signals are shown is *one hundred and eleven.* The points whence storm-signals are displayed, however, are only those of the maritime margins of the field of research.

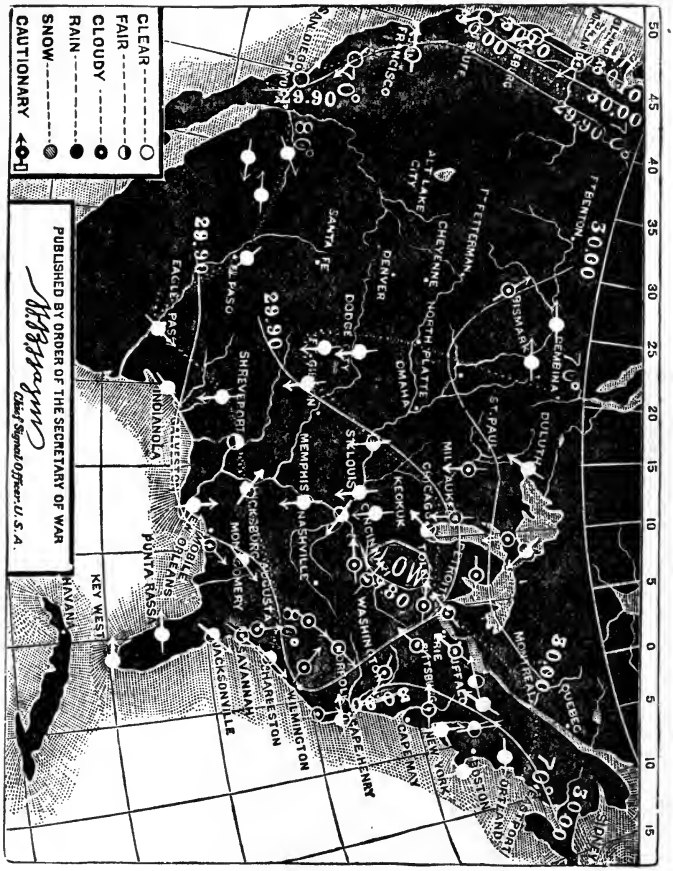
*Practical Use of Weather Reports.*—In referring to the wide-spread interest in the weather predictions of the past few years, a recent winter in the "Quarterly Review" observes, "some basis of solid value to the public must exist to account for such a general popularity of the weather service."

The tri-daily "Indications" are designed to give timely notice of the general weather changes to occur in the twenty-four hours following their issue. As they are telegraphed from the Washington office, and adopted to the convenience of the daily press, they are greatly condensed to bring the cost of telegraphing with the restricted means of the service; and yet they must be made sufficiently full to cover the whole country. These conditions are hinderances to their usefulness, and the brevity of the dispatches expose them at times to popular misrepresentation. But, notwithstanding these drawbacks, the scope of their practical application to all classes of industry is large and continually increasing. When this weather bureau was first proposed, the highest end thought attainable by the most sanguine was to give warnings of the *great* storms that traverse the lakes and sea-coast of the United States. This, however, is but a small part of the public interests it subserves. The number of persons who find that the reports and forecasts of the service may be utilized for every-day life is constantly increasing. Signal observers are frequently summoned to bring their weather records into court as evidence. Grain and cotton merchants make the reports valuable in calculations of the forthcoming crops. Emigrants consult them in the selection of favorable climatic conditions for a new abode. Physicians, sanitarians, and boards of health employ the data to detect dangerous conditions of the atmosphere of the cities, and for investigating the origin and spread of diseases and epidemics, as in the case of recent yellow-fever visitations of the south. The pork-packers, fruit-importers, and fish and oyster-dealers keep an eye on them to secure themselves against exposure of perishable goods to extremes of temperature or other vicissitudes of weather. They are of use to specialists in manufacturing and to hygienic interests, and are consulted by thousands planning journeys or excursions for health or pleasure. River boatmen, farmers, sugar-planters, fruit-growers, ice dealers, and many other interests, find occasion to utilize them. Mechanics judge from the prognostics whether they can work outside on the morrow. The meteorological data supply engineers with information indispensable for planning economical and storm-proof architecture. Railroad officials (steam and horse), during snow-blockades, are kept advised by the reports, so that they are enabled to make provisions for clearing the tracks; and railroad freight officers find them useful for facilitating transportation.

These are some of the daily applications made of the Signal Service work in the interior and central, not less than in the seaboard sections of the country. In every branch of agriculture and trade the deductions made from the published synopsis and indications of the weather, have acknowledged value to the public when obtain-

able. In military operations the intelligence of approaching storms is highly prized in timing movements so as to avoid heavy roads and dangerous delays. "Had we a quarter of a century ago," says a British meteorologist, "known the rigor of the Crimean climate, who would have dared to send out an army unprepared to meet the hardships of a Black-sea winter? Ask the physician at what price he would value the power of giving timely warning of a 'cold snap' to his patients. Ask the builders of London what they have lost in the last ten years by sudden frosts, or unexpected downpours of rain. Above all things, go to the farmer and ask what he would freely pay to know at seed time what weather he might really expect in harvest. The fact is, there is not a profession, not a handicraft, not a process in animal or vegetable life, which is not influenced by meterological changes."

*Private forecasts.*—To faciliate such private forecasting, General Myer caused to be prepared the "Weather Case," or "Farmer's Weather Indicator." This instrument is very simple, and it is hoped agriculturists and persons of ordinary education will find it possible to determine for themselves in advance, the character of the




War Department Weather Map, a daily meteorological chart transmitted by telegraph from Washington.

weather from local indications. At isolated places where the reports cannot be had, the diligent practice of such forecasting would probably in a short time afford good results. The Signal Service has always encouraged the private study and intelligent local application of its press-reports, and expects those who use them, to consult their own barometers and other instruments, and to examine the local signs of

the weather, as clouds, &c., with the view of giving greater efficacy to its necessarily brief telegrams.

In the execution of the last-named plan, the "Daily Graphic" of New York City, publishes daily, a reproduction of the Signal-Service weather map, showing the barometer, thermometer, wind, rainfall, and other conditions prevailing over the country at the time of going to press. These charts, according to a plan devised in this office, have been transmitted from the Washington office by telegraph. By an ingenious device, it is found not difficult to transmit to any city reached by telegraph—and by the common telegraphic instrument—such data prepared in the Chief Signal Office, as will enable any newspaper to reproduce on its pages the official weather-map for the current period. Thus the Signal-Service weather-map for 1 a. m. of any date, precisely as charted in the Washington office, can be telegraphed to Boston, Chicago, Saint Louis, Indianapolis, or any other city, and published in any size the editors may prefer, in the papers printed *that morning*. The adoption of this method of popularizing and disseminating weather knowledge, while the public interest in the data is fresh, has been received with great satisfaction in New York City, and its general extension to all sections of the country will vastly diffuse the benefits of the Service. It may seem trivial to dwell upon apparently slight changes in barometric and other conditions which are curiously glanced at on the weather-map; but a moment's reflection shows the importance of accuracy. Minute but common barometric changes, representing forces of great moment in the operation of the atmospheric machinery, must not be overlooked in the deductions of practical meteorology. But without the weather-map of simultaneous observations, the presence and influence of such changes cannot be detected and estimated.

## SIGNAL-SERVICE INSTRUMENTS.

The necessity for accurate observations in a system of weather telegraphy brings us to speak of the instruments employed by the Signal-Service. These have been selected from the best models known, and subjected to experimental tests to perfect their registrations. Every barometer, thermometer, or other instrument used at the stations, undergoes thorough comparison with the highest standards before it is sent out from the Office of the Chief Signal Officer, in which there is a large apartment devoted to this work, known as the "Meteorological Observatory."

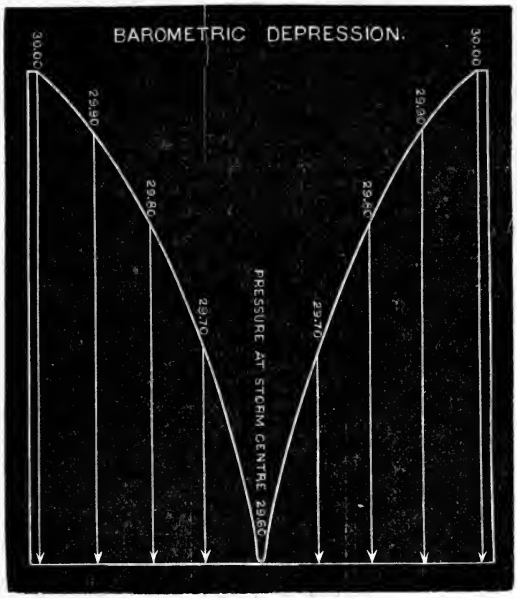


Diagram of pressure in a section of a cyclone.

The barometer is the great dependence of the meteorologist and upon its faithful accuracy in registering the subtile yet momentous changes of atmospheric pressure he must chiefly rely. It measures the pressure at the spot where it is located,

Fortin's barometer, as manufactured by Messrs. J. and H. J. Green of New York City, is the one used by the Signal Service at all its stations. The

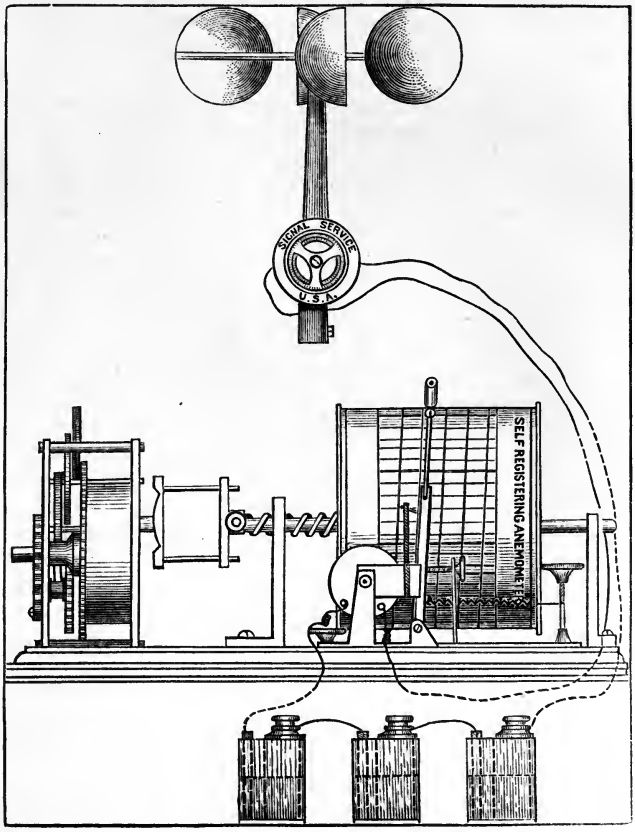
instrument is kept in a room of as uniform a temperature as practicable, and in a vertically suspended wooden box which can be closed when the observer is not taking observations. For purposes of comparison and the detection of any error, as well as to have a substitute in case of accident, two barometers are supplied to each station. Each instrument after it comes from the maker's hands is subjected to the signal-office tests, and the correction for instrumental error is determined by comparison with the standard barometer kept at the office, when a certificate of correction is made out and attached to the instrument. Its readings may deviate to a very slight extent from those of the standard; but such deviations being known to a thousandth part of an inch, allowance as made for them whenever the observer makes his barometric report. As the elevation of the barometer above sea-level is determined for each station, the proper correction for that is also applied at each reading.

Great care is taken in the location, correction, and reading of the service thermometers. The instrument is placed in the open air, so situated that it will always be in the shade and yet have a free circulation of air around it, and beyond the influence of any artificial heat. Its surface is also carefully protected and kept free from rain or moisture of any kind, and its bulb so placed as to have no contact with the metallic scale or back. Every thermometer sent out to a signal station undergoes careful comparison with the standard kept in the central office and is furnished with a certificate of corrections. The maximum and minimum thermometers are likewise tested, and the slightest variations from the standard instruments determined by protracted experiments, to the satisfaction of the office, before they are issued to the observers. These instruments, by the constant and minute inspection of officers detailed to visit all the stations, as also by the rigid scrutiny of the observers themselves, are kept up to a high point of accuracy and precision. In the central office, 1,357 meteorological instruments were, in 1883, carefully compared with the "official standards," and issued to the stations.

The rain-gauges employed are of uniform pattern, and register the amount of precipitation to inches and hundreths of an inch. They are placed with the tops at least twelve inches from the ground, and in such places as not to be affected by local peculiarities or obstructions. They are firmly fixed in a vertical position, and beyond the risk of being tampered with by unauthorized hands. The rain-water collecting in them is measured by a measuring-rod, graduated to inches and tenths of inches; snow is melted and then measured in the same way.

The wind-velocity measurer or anemometer, which up to the present time has been found the most satisfactory, is that of Robinson. It consists of four hemispherical cups revolving in a horizontal plane and communicating their motion to a vertical shaft or axis. In whatever direction the wind blows, these cups will always be driven around with their convex sides foremost, since the air presses with more effect into the cups than on their exteriors. Experiments have shown that the velocity of the cups in all cases is approximately one third of that with which the wind blows, no matter from what point of the compass it comes; and that this relation between the velocity of the cups and that of the winds is independent of the size of the instrument. As the distance travelled by the cups is three times that travelled by the wind, the velocity of the latter can be easily deduced. Generally it is placed twenty feet above the roof of the building in which the office is located. In some American storms the wind has been found to blow with the tremendous velocity of from one hundred to one hundred and thirty-eight miles per hour, and it is difficult to find or frame an anemometer, which while delicate enough to register small disturbances, will be strong enough to stand the force of such hurri-

canes. But the experiments of the Signal Service, it is hoped, will lead to some instrumental improvement in this direction.




Signal Service anemometer, with self-registering attachments.

The Signal Service has endeavored to obtain barometers, thermometers, &c., which will be self-recording, and give, without manipulation, continuous, exact, and graphic registers of the atmospheric fluctuations. Numerous ingenious contrivances have been for years under careful testing by the office, with the view of securing forms adapted to general use on stations.

## THE INTERNATIONAL WEATHER SERVICE.

This novel and vast extension of the national work done by the United States weather service is perhaps the most remarkable feature in the development of modern meteorology. Previous to the adoption of the system of "simultaneous" weather-reports by General Myer in 1870, comparatively few observations had been taken in any country that could be strictly called simultaneous, suitable for the preparation of synoptic weather-charts, or that could be regarded as strictly intercomparable; but, in each country where weather-reports on a large scale were made, they were prepared from daily observations made at moments of time more or less widely separated. The organization and successful working of a weather bureau upon such a simultaneous system in the United States prepared the way, however, for an international weather service. Accordingly, when in September, 1873, an Interna-

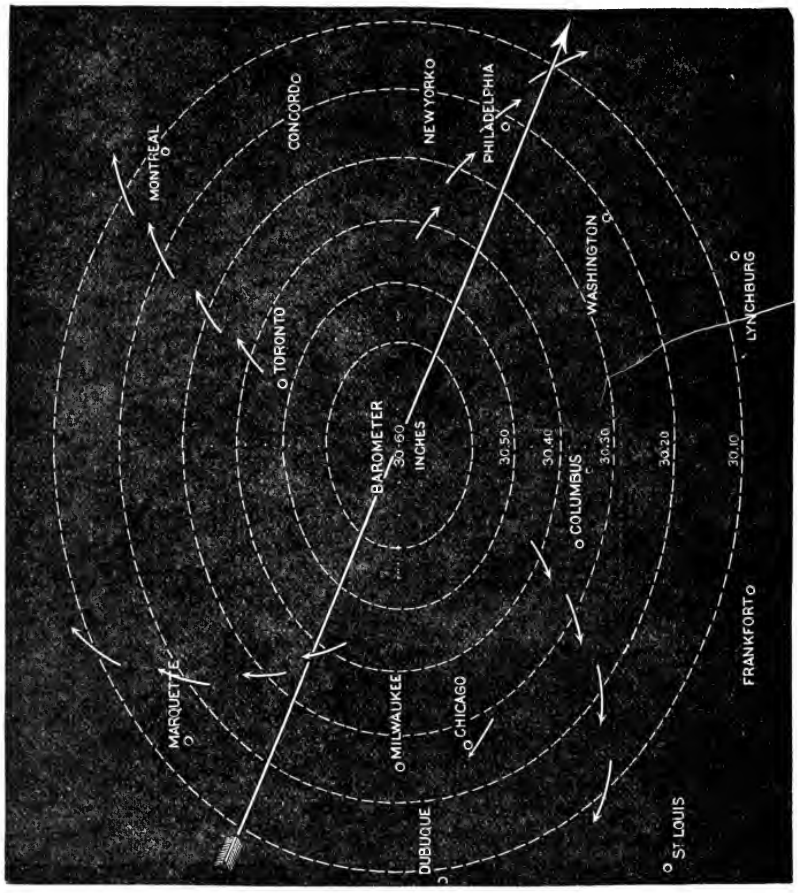
tional Meteorological Congress was convened at Vienna—an assemblage composed of the official heads of the meteorological bureaus of the different powers—an original proposition was made by General Myer, as the Chief Signal Officer of the United States Army, looking toward a world-wide scheme of weather research. General Myer's proposition was to this effect: "That it is desirable, with a view to their exchange, that at least one uniform observation, of such character as to be suited for the preparation of synoptic charts, taken and recorded daily at as many stations as practicable throughout the world." The author of this proposition had in his report to the United States Congress, in 1872, expressed a desire for such a cosmopolitan work—"a grand chain of interchanged international reports, destined with a higher civilization to bind together the signal service of the world"; and the Vienna conference now responded to his overture with alacrity. The atmosphere is a *unit*, and to be understood must be studied as a unit; and to comprehend the forces which conspire to make a single cyclone, we must extend our investigation far beyond our territorial limits.

The adoption of General Myer's proposition by the Vienna Congress, and the courteous co-operation on the part of all the leading governments of Europe, soon enabled him to collect materials for laying the foundation of international research. Rapidly expanding, in 1874, the exchange of simultaneous reports became numerous enough to admit of making a daily "Weather-Bulletin and Chart;" and on January 1, 1875, the signal office at Washington commenced the daily publication of the "Bulletin of International Simultaneous Meteorological Observations, of the northern hemisphere," presenting the tabulated results of simultaneous weather-reports from all the co-operating observers. These reports to cover the combined territorial extent of Algiers, Australia, Austria, Belgium, Central America, China, Denmark, France, Germany, Great Britain, Greece, Greenland, India, Ireland, Italy, Japan, Mexico, Morocco, the Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, Tunis, Turkey, British North America, the United States, the Azores, Malta, Mauritius, the Sandwich islands, South Africa, South America, and the West Indies, so far as they have been placed under meteorological surveillance; and also the great ocean highways, on which the ships of all flags take observations while *en route* from port to port.

As early as July 1, 1878, in connection with the daily International Bulletin, General Myer began the daily publication of a graphic synoptic "International Weather Map." This chart covers the whole international net-work of observations, and is the supplement and key to the daily bulletin, both being based on the same data, and both of the same date. The "International Weather-Map of Simultaneous Observations" exhibits the aerial phenomena as they actually existed all around the earth at a fixed moment of time.

In carrying out this international enterprise the Signal Service has the co-operation of the British, Portuguese, Swedish, and American navies. It also has the co-operation of the Pacific Mail Steamship Company, White Star Line, Occidental and Oriental Steamship Company, North-German Lloyd, American Steamship Company, Red Star Line, Allan Line, and others. The daily bulletins and charts prepared from the collective data are mailed to every co-operating observer without charge, as an acknowledgment of his service to science, and constitute in themselves an invaluable meteorological library. In the case of maritime observers, the Signal Service bears the expense of blanks, postage, etc.; and when necessary it furnishes the ship-master with the requisite instruments. The number of marine observers is 481, and all navigators are requested to contribute to this system of reports. As a striking illustration of the opportunities which a vessel at sea has for aiding in this meteorological work, it may be mentioned that the steamship "Faraday," when laying the last Atlantic cable, encountered a severe cyclone in mid-ocean, which,

without heaving to, she reported by her telegraphic wire to Europe, noting the successive changes of wind as the different quadrants of the storm passed over her; thus indicating to those on land the direction and progressive velocity of the gale, so that they could calculate the time and locality at which it would strike upon the European coasts.




An anticyclone, or wave of high barometric pressure from the northwest. Large arrow shows direction of its progress; small arrows show its winds.

If, as General Myer held, it is practicable to establish floating stations in mid-Atlantic, connected by cable with the continent, the reports from such posts would be of incalculable value to British and continental meteorologists in making out their daily weather forecasts and ordering storm-warnings for their sea-ports.

The proposition of General Myer at Vienna, in 1873, was that observations be taken daily and simultaneously at as many stations as practicable "throughout the world." A recent meteorological conference at Hamburg recommended a concert of all nations for planting a cordon of weather observatories in high northern and southern latitudes around the poles. Indeed, there is scarcely a problem relating to the physical geography and meteorology of our own country which can be fully solved without recourse to more extended investigations outside of the United States. The international weather service is the great hope of the meteorology of the future.

In addition to the daily international charts published by the Chief Signal Officer

*monthly international charts* of the northern hemisphere, displaying the monthly storm-tracks, isobars, isotherms, and prevailing winds, are issued. These charts are now published in the "Monthly Summary and Review," a publication sent to all observers, on land and sea, who co-operate with the Signal Service in its international research. To aid ship-masters of every flag in keeping their instruments correct, the Chief Signal Officer has also placed standard barometers at the ports of New York City, San Francisco, and elsewhere for reference and comparison. Without pecuniary charge to foreign or American ships, their barometers, on application to the signal office at these ports are carefully tested, adjusted, and corrected for effective use at sea.

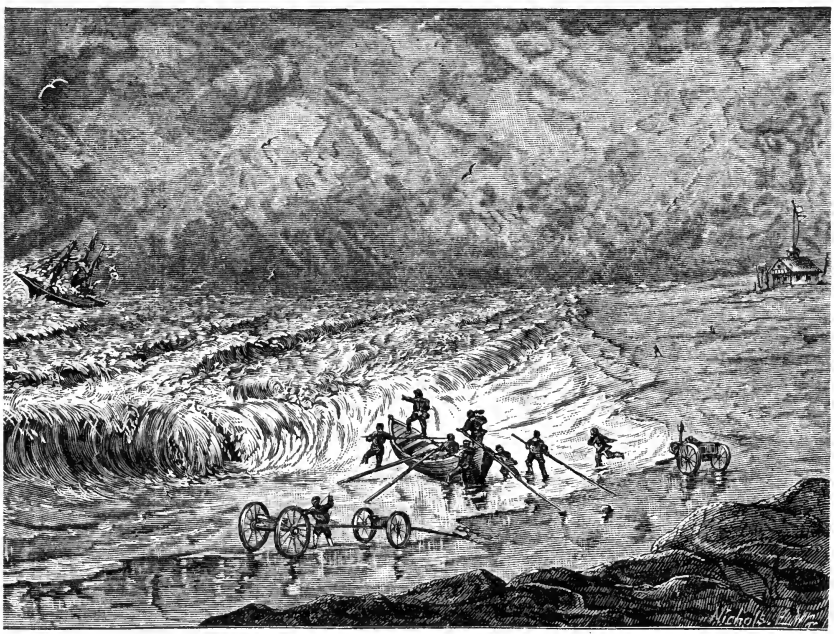
With the extension and collation of the international weather-reports, we may hope, as General Myer has said, that "the questions as to the translations of storms from continent to continent, and of the times and directions they may take in such movements; the movement of areas of high and low barometer; the conditions of temperature, pressure, etc., existing around the earth at a fixed instant of time, as well as questions of climatology and others bearing upon the prediction of weather changes far in advance of the time at which these changes happen, or queries as to the character of coming seasons, may be settled." If the Signal Service undertook no other duty than the collection of materials for the construction of the science of international meteorology and climatology, it is not too much to say that the harvest of observational data thus garnered would ultimately be worth all the labor and expense the service has cost the Government. But, to secure such results, it cannot be too widely or urgently insisted on that navigators, ship-owners, steamship companies, and all naval officers should use their earnest efforts and influence to obtain simultaneous weather-reports from all sea-going steamers and saling vessels. The ablest scientific journal of Great Britain, "Nature," recently said that it "earnestly hopes that the navies and mercantile vessels of all nations will soon join in carrying out this magnificent scheme of observations, originated by the Americans in 1873 and since then further developed and carried on by them with the greatest ability and success." Sentiments similar in effect were expressed at the International Meteorological Congress convened in Rome, Italy, in April, 1879.

The sea-coast telegraph lines are another important portion of the organization. By act of Congress, the Secretary of War was authorized to establish signal stations at the light-houses and life-saving stations on the lakes and sea-coasts, and to connect these signal stations with telegraph lines, to be constructed, maintained, and worked under the direction of the Chief Signal Officer of the Army; and the use made of the life-saving stations is subject to such regulations as are fixed upon by the Chief Signal Officer, the Secretary of War, and the Secretary of the Treasury. By this co-operative arrangement, the Signal Service has become a valuable, if not indispensable auxiliary to the sister services with which it connects, and shares very materially in their labors and responsibilities.

The coast signal stations aim to warn vessels within signalling distance, of the approach of storms, and to give life-saving stations quick notice of marine disasters calling for rescue, as also to furnish any intelligence to the latter, or to the light-houses, which may insure their more efficient working. Connected by wire or submarine cable, as all the signal stations on the sea-coast are from Sandy Hook, New Jersey, to Smithville, North Carolina, and connected similarly with the Office of the Chief Signal Officer at Washington, whence they are kept advised of any change in the meteorological status, they are thus enabled, from their full ocean view, to communicate directly any warnings from the Chief Signal Officer to passing ships, or to convey to him any facts which may be of use to the Washington office. The telegraphic wires connect each station with the central office. The weather reports and observations of the indications of the sea thus obtained,

are often of the greatest value to the Washington office in its work of pre-announcing the force, direction, and velocity of the great hurricanes from the West Indies which traverse our Atlantic seaboard.

As an illustation of this, it may suffice to note that in the summer of 1873, when the great August hurricane, which so furiously assailed and wrecked several hundred sail, was still passing over the Bermudas, its long, dead swell was outrunning its centre by 600 miles, driving in the bathers at Long Branch and pouring into New York bay, The steamer "Albemarle" encountered its fore-running wave on the voyage from Halifax to the Bermudas, and, though the morning was fair, suspecting danger, the vessel was hove to for a few hours to examine the swell. Concluding that the hurricane was advancing directly upon him, her captain changed his course from southerly to westerly, and by a slight *detour* eluded the gale.



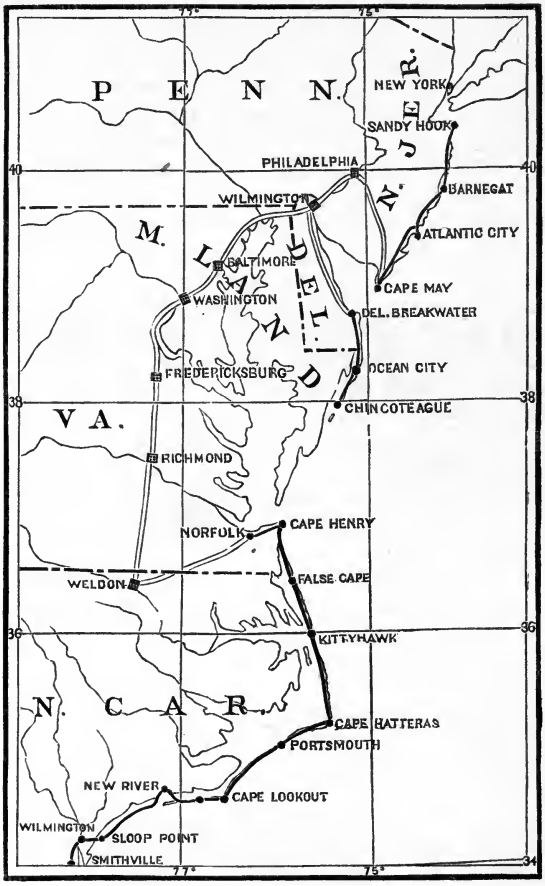
The Signal-Service station at Cape Henry signalling to the stranded bark "Pantzer."

As one by one, yet all independently, the coast signal observers on any day telegraph to the central office the same significant tidings of the ocean indications of an Atlantic gale—the intensity and direction of the swell—their concurrent observations often present unmistakable proofs of the presence, course, and progressive rate of these menacing storms. The intelligence thus afforded is indispensable to the storm-warning and weather-prediction work of the Washington authorities.

But, apart from the meteorological value of such a coast Signal Service, its incidental contributions to the life-saving stations have already proved of the greatest assistance.

On the 22d of March, 1877, after a severe storm on the middle Atlantic coast, Sergeant William Stein, of the Signal Corps, in charge of the Cape Henry station, discovered before dawn a large vessel stranded on a shoal off that station, and summoned the wreckers at Norfolk to come to the rescue. With the earliest light the sergeant displayed the "attention flags" of the international code, with which every sea-coast signal-station is supplied, and receiving answer that she was the "Win-

chester," of Liverpool, with request for two steam-tugs to be sent to the vessel, he telegraphed at once to Norfolk for wrecking-steamers. Before sundown active efforts were made to save the stranded vessel. She was gotten off the shoal after some days' labor; but, meantime, three other vessels, in a second storm (of the 25th), were stranded within a mile of her. Sergeant Stein again telegraphed the wreckers at Norfolk for aid. He ascertained the name of the bark in greatest peril to be the "Pantzer," a Norwegian vessel, and the crew of the life-saving service a little later succeeded in firing a life-line over her deck. The Norwegians did not comprehend its use, but after some effort the signal-service officer, by means of international signals, instructed her crew to "haul in on the line," and by nine o'clock all the crew of the "Pantzer" were safely landed. In the wrecks of the steamships "Huron" (of the United States Navy), "L'Amérique," and "Russland," the first tidings were conveyed by the Signal-Service wires, and through them succor was speedily summoned. In the case of the "Huron," drifted ashore near Kitty Hawk, a private of the Signal Corps, A. T. Sherwood, stationed at that place, received the first intelligence November 23d, and, after telegraphing to Washington, hastened to the awful scene, walking sixteen miles through the sand, and brought full reports of the situation to his station, which were instantly telegraphed to the Chief Signal Officer. The War and Navy Departments and the Life-saving Service were thus notified, and by them steamers of the navy and wrecking companies were started to the fatal point of the shore on which the "Huron" had gone to pieces. The Kitty Hawk observer immediately on receiving orders from the Chief Signal Officer, opened a "wreck-station" abreast of the foundered vessel before daylight of the 25th, connecting it by a temporary telegraph-wire with his station, and, working this improvised station on the open beach, while the gale was yet raging, drew toward the spot the whole organized relief force of the government.




Signal-Service sea-coast telegraph-lines.

A similar service was performed on the stormy night of January 31, 1878, by another private soldier of the Signal Corps, William Davis, when the steamship "Metropolis," with 248 souls on board, became a total wreck, twenty miles from Kitty Hawk station. At 6.55 p. m. on that night, intelligence of the disaster reached Kitty Hawk, and in less than fifteen

minutes Private Davis, carrying telegraphic and signal apparatus, was riding through the night and storm to the scene. By 4 a. m. he had reached the vessel, established his telegraph station abreast of her, opened communication, and fowarded a report to the Chief Signal Officer at Washington, and was putting in motion all the machinery of relief and succor which the country could command. The observers of the coast signal-station, whenever it is practicable, *board* vessels that have gone ashore, and open communication with the land. An instance of this may be cited from the action of Private Harrison, of the Signal Corps, at Cape Henry, when the bark "Guisseppe Masson" was wrecked near that station, February 10, 1878. His presence prevented the crew from deserting their ship, which, by the aid of powerful wrecking-steamers, was subsequently saved. Other instances of boarding vessels could be cited as those of the Italian bark "Francesco Bellagambe" and the British steamship "Antonio," both boarded by Signal Service men, who afterward kept up signal conversation with the shore until the ships were saved. These cases will suffice to show the intimate alliance existing between the coast Signal Service and the results announced by the Life-saving Service. Without the Signal Service co-operation, the latter would often, in emergencies that arise, be powerless to command the needed help, as well as communicate with stranded vessels. For the Signal Service, only men drilled in signalling can avail.

So arranged is the coast Signal Service, that not only are its storm-flags and danger warnings visible to vessels moving off the coast, but, even a vessel moving *en voyage* (say one which is bound from the equator to New York), as she passes Cape Henlopen, may inquire by signals whether any hurricane is impending; if so, whether she has time to reach Sandy Hook before its arrival, or must take shelter behind the Delaware breakwater. Or a vessel bound from New York or any northern port, southward, on reaching the capes of the Delaware, can make inquiry as to whether any storm is likely to strike her before she can make Cape Hatteras, and receive full advice by telegraph from the Chief Signal Officer at Washington, in a very brief time. With adequate appropriations, this coast Signal Service could easily be made of far greater value to all the shipping and mercantile interests.

As the Chief Signal Officer has said: "The time is not far distant when the possession of a coast not covered by sea-coast storm-signal and Signal Service stations, watching as sentinels each its own beat of sea and shore, and ready to summon aid by electric wires, will be held as much an evidence of semi-barbarism, as is now among civilized nations the holding of any national coast without a system of light-house lights." In event of war, with a completed chain of coast signal-stations, no part of our exposed sea-coast could be threatened without immediate intelligence of the fact being flashed to the Washington office and all along the coast, and the defensive power of the government concentrated at the point endangered. The chain of telegraphic sea-coast stations at present is six hundred and ten miles long, stretching from Sandy Hook to the mouth of Cape Fear River.

The military telegraph system constructed, owned, and operated by the Signal Service, is more extensive than the sea-coast system mentioned. In pursuance of acts of Congress, this service has now completed in the interior and upon the frontier an extensive net-work of telegraph lines for connecting military posts, with a view to the protection of the population from Indian depredations, and the transmission of meteorological, military, and other reports to the Government. A total length of 2,803 miles of frontier line is now operated and maintained by the Signal Service. This connected system of telegraph lines is one of the most effective safe-guards against Indian raids and warlike movements, since it enables the scattered military forces of the United States to obtain timely notice of such movements, and to concentrate quickly at any threatened point to repel attack. The Indian strategy is to pass between the Government army posts unobserved, so that their plans may

not be reported, a very difficult thing in a region traversed by electric wires. To break them is to announce their purpose and betray themselves, alarming the post and settlements on both sides of the break, and evoking spirited pursuit and severe punishment by the troops. As an engine of civilization, the frontier telegraph rivals the railway, enabling the Government to throw an ægis of protection over the rapidly expanding wave of western emigration, and thus facilitating, no doubt, the sale and settlement, as well as the material development of the public lands. These Signal Service lines are in part self-supporting, as they transmit not only Government but private telegrams of the civilian population, and save the expense of telegraphing by other lines the meteorological reports necessary for the weather work at Washington, besides serving to convey a great number of official dispatches and correspondence for various departments of the Government, that would otherwise have to be transmitted, at considerable cost, on non-govermental lines, or sent by couriers.

But apart from all the incidental benefits and economies wrought by this frontier telegraph system, its value in the scientific work of the weather-bureau proper, is felt to be the greatest. The lines in Texas have made it possible to furnish weather-reports daily on the coast of that state ; and those in the northwest permit a series of observations and reports not otherwise attainable, which are of the first importance for all purposes of weather prediction throughout the United States. Meagre as the data now obtainable from the northwest are, they are indispensable for the processes of weather telegraphy in the Mississippi valley and lake region. To study these momentous meteorological agencies and to receive timely notice of their arrival on the *extreme northwestern* frontier, is perhaps the most important task, so far as weather prognostication goes, that the Signal Service could pursue. The extension of its telegraphic and observational stations in this direction would immensely enhance its general effectiveness and give fresh stimulus to almost every meteorological investigation which the service is now pushing.

The length of Signal-Service telegraph lines in the interior and on the frontier at present is as follows : Arizona Division 510 miles, with 13 stations ; Texas Division, 197 miles, with 5 stations ; the Northwestern Division, 893 miles, with 20 stations ; the Washington and Idaho Division, 500 miles, with 18 stations ; the Division of the Military Department of the Missouri, 703 miles, with 17 stations ; total 2803 miles, with 73 stations.

In concluding this necessarily much condensed sketch of the national weather-service, its pressing wants should not be overlooked. No other service appeals so strongly to the interests which it daily subserves for intelligent co-operation. The public press can do much to advance its development by systematic republication and explanation of its observations and deductions, and especially by reproducing the data furnished in its "Monthly Weather Review," and in the daily telegraphic "Synopsis." Time and toil are necessary to harvest the fruit of seeds sown ; but, as the President of the American Geographical Society, Chief Justice Daly, has said :

"Nothing in the nature of scientific investigation by the national government has proved so acceptable to the people, or has been productive in so short a time of such important results, as the establishment of the Signal Service bureau."

# LIST OF PUBLICATIONS OF SIGNAL OFFICE.

## ANNUAL REPORTS.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1870.* | 1872. | 1874.* | 1876.* | 1878.* | 1880. | 1882.* |
| 1871. | 1873.* | 1875.* | 1877. | 1879. | 1881. | |

## PROFESSIONAL PAPERS (quarto).

I. General Report on the Solar Eclipse of 1878.*—Professor Abbe.

II. Isothermal Lines of the United States, 1871–1880.—A. W. Greely, 1st Lieutenant, 5th Cavalry.

III. Chronological List of Auroras.*—A. W. Greely, 1st Lieutenant, 5th Cavalry.

IV. Tornadoes of May 29 and 30, 1879.—John P. Finley, 2d Lieutenant, Signal Corps.

V. Information Relative to the Construction and Maintenance of Time Balls.*—Compiled by Prof. W. Upton from sundry sources.

VI. The Reduction of Air Pressure to Sea-Level at Elevated Stations West of the Mississippi River.—Prof. H. A. Hazen.

VII. Report on the Character of Six Hundred Tornadoes.—John P. Finley, 2d Lieutenant, Signal Corps.

VIII. The Motion of Fluids and Solids on the Earth's Surface.—Prof. W. Ferrel—Notes by Prof. F. Waldo.

IX. Charts and Tables Showing Geographical Distribution of Rainfall in the United States.—H. H. C. Dunwoody, 1st Lieutenant, 4th Artillery.

X. Signal Service Tables of Rainfall and Temperature Compared with Crop Production.—H. H. C. Dunwoody, 1st Lieutenant, 4th Artillery.

XI. Meteorological and Physical Observations on the East Coast of British America.—O. T. Sherman.

XII. Popular Essays on the Movements of the Atmosphere.—Prof. W. Ferrel.

XIII. Temperature of the Atmosphere and Earth's Surface.—Prof. W. Ferrel.

## SIGNAL SERVICE NOTES (octavo).

I. Report on the Michigan Forest Fires of 1881.—W. O. Bailey, Sergeant, Signal Corps.

II. Memoir on the use of Homing Pigeons for Military Purposes.—W. E. Birkhimer, 1st Lieutenant, 3d Artillery.

III. To Foretell Frost.—James Allen, 1st Lieutenant, 3d Cavalry.

IV. The use of the Spectroscope in Meteorological Observations.—Prof. Winslow Upton.

V. Work of the Signal Service in the Arctic Regions.*—Mr. W. M. Beebe, J. S. Powell, 2d Lieutenant, Signal Corps, P. Henry Ray, 1st Lieutenant, 8th Infantry.

VI. Report on Wind Velocities at the Lake Crib and at Chicago.—Prof. H. A. Hazen.

VII. Variation of Rainfall West of the Mississippi River.—Prof. H. A. Hazen.

VIII. The Study of Meteorology in the Higher Schools of Germany, Switzerland, and Austria.—Prof. Frank Waldo.

* Editions exhausted.

IX. Weather Proverbs.—H. H. C. Dunwoody, 1st Lieutenant, 4th Artillery.

X. Report on the Lady Franklin Bay Expedition of 1883.—E. A. Garlington, 1st Lieutenant, 7th Cavalry.

XI. The Elements of the Heliograph.—F. K. Ward, 1st Lieutenant, 1st Cavalry.

XII. The Special Characteristics of Tornadoes.—John P. Finley, 2d Lieutenant, Signal Corps.

XVI. The Effect of Wind Currents on Rainfall.—G. E. Curtis, Sergeant, Signal Corps.

MISCELLANEOUS (octavo).

Official, Danger, Distress, and Storm Signal Code, for Signal Service Sea-Coast Stations and Mariners.

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## TO BE ISSUED SOON.

PROFESSIONAL PAPERS (quarto).

XIV. Charts of Relative Storm Frequency for a Portion of the Northern Hemisphere.—J. P. Finley, 2d Lieutenant, Signal Corps.

XV. Researches on Solar Heat and its Absorption by the Earth's Atmosphere.—Prof. S. P. Langley.

SIGNAL SERVICE NOTES (octavo).

XIII. The Relation between Magnetic Storms and Northers at Havana, Cuba.—G. E. Curtis, Sergeant, Signal Corps.

XIV. Physical Observations on board the Lady Franklin Bay Expedition of 1883.—W. H. Lamar, Jr., and F. W. Ellis, Sergeants, Signal Corps.

XV. River Floods and Danger Lines of 1882.—Prof. H. A. Hazen.

XVII. A First Report upon Observations of Atmospheric Electricity at Baltimore, Maryland.—Park Morrill, Private, Signal Corps.

MISCELLANEOUS (large quarto).

How to Use Weather Maps.

# CATALOGUE OF SIGNAL SERVICE INSTRUMENTS.

| Kind of instrument, etc. | Maker. |
|---|---|
| Achromatic triplet | Toll. |
| Actinometer | Stewart. |
| Actinometer | Violle. |
| Air-meter | Casella. |
| Air-meter | Birams. |
| Aeliograph | Clum, |
| Air pump | |
| Altazimuth instrument | |
| Anemoscope, self-recording | Beck. |
| Anemoscope, self-recording | Eccard. |
| Anemoscope, self-recording | Wild. |
| Anemometer | Hahl. |
| Anemometer | Hageman. |
| Anemometer, self-recording | Hipps. |
| Anemometer, self-recording | Wild. |
| Anemometer | Lind. |
| Anemometer, self-recording | Eccard. |
| Balance | Beck. |
| Barometer, self-recording, electric | Eccard. |
| Barometer, self-recording, electric | Foreman. |
| Barometer, marine, electric | Hahl. |
| Barometer, Gibbons, self-recording | Hahl. |
| Barometer, Hough, self-recording | Fasaldt. |
| Barometer, mechanical | Peeler. |
| Barometer, balance | Wild. |
| Barometer, photographic | Beck. |
| Barometer, transmitter, self-recording | Eccard. |
| Barometer, aneroid, self-recording | Hipp. |
| Barometer, aneroid, self-recording | Beck. |
| Barometer, aneroid, self-recording | Hottinger & Co. |
| Barometer, standard | Green. |
| Barometer, sub-standard | Aidie. |
| Barometer, sub-standard, control | Füss. |
| Barometer, sub-standard | Casella. |
| Barometer, mountain | various makers. |
| Barometer, marine | various makers. |
| Barometer, aneroid | various makers. |
| Cathetometer | Casella. |
| Chronometer | Negus. |
| Chronograph | Hipp. |
| Compass | various makers. |
| Compass, prismatic | various makers. |
| Compass, surveyor's | various makers. |
| Comparator thermometer | Professor Russell. |
| Comparator thermometer | Yale College. |
| Condenser, electric | |
| Dynameter | |
| Electrometer | Tompson. |
| Electrometer | Siemen. |
| Electroscope | various makers. |
| Glasses, eye | |
| Glasses, marine | various. |
| Grating, diffraction | Lockyer. |
| Gauges, rain | various. |
| Gauges, river | various. |
| Gauges, snow | various. |
| Galvanometer, reflecting | Tompson. |
| Galvanometer, Siemen | Siemen. |
| Galvanometer, Sine | W. U. Tel. Co. |
| Heliometer | Becker. |
| Heliostat | various. |
| Heliograph | various. |
| Hydrometer | various. |
| Hygrodeik | Low. |

| Kind of instrument, etc. | Maker. |
|---|---|
| Hygrodeik | Dunwoody. |
| Hygrometer | Schwackoffer. |
| Hygrometer | Edelman. |
| Hygrometer | Dyne. |
| Hygrometer | Koppe. |
| Hygrometer | Mason. |
| Hygrometer | Sausures. |
| Hygrometer | Regnault. |
| Hygrometer | Alluard. |
| Hygrometer, self-recording | Wild. |
| Hygrometer, self-recording | Hough. |
| Indicator, wind | various. |
| Indicator, cautionary | various. |
| Knapsack, wrecking | |
| Levels | various. |
| Marine lanterns | |
| Mortar, gun-cotton | |
| Mortar, signal | |
| Nephelescope | Green. |
| Ozonometer | |
| Odometer | |
| Pistols, signal | |
| Pyrometer | Casella. |
| Pneumatometer | Edelmann. |
| Pedometer | |
| Rod, telescopic, anemometer | |
| Rod, telescopic | |
| Sextant | |
| Shelter, instrument, window | |
| Shelter, instrument, roof | |
| Signal lanterns | |
| Spectroscope, large | Lockyer. |
| Spectroscope, small, rainband | Lockyer. |
| Signal kit, containing: | |
| Canteen and strap | |
| Canvas case and strap | |
| Foot torch extinguisher | |
| Flying torch extinguisher | |
| Flag, 4-feet, white | |
| Flag, 4-feet, red | |
| Flame shade, foot torch | |
| Flame shade, flying torch | |
| Funnel | |
| Haversack | |
| Pliers | |
| Scissors | |
| Staffs, jointed | |
| Straps | |
| Foot torch | |
| Flying torch | |
| Wormer, torch | |
| Special apparatus: | |
| Barometer testing apparatus | Hahl. |
| Boiling point apparatus | Pernet. |
| Boiling point apparatus | Negretti & Zambra. |
| Calibrating apparatus | Pernet. |
| Distilling apparatus, mercury | Professor Wright. |
| Freezing point apparatus | Pernet. |
| Fog measuring apparatus | Schwackoffer. |
| Pendulum apparatus | Kater. |
| Telescope | |
| Thermometer; air | Jolly. |
| Thermometer, normal | Tounelot. |
| Thermometer, normal | Baudin. |
| Thermometer, normal | Green. |
| Thermometer, exposed | various. |
| Thermometer, maximum | various. |
| Thermometer, minimum | various. |
| Thermometer and case, water | various. |
| Thermometer, radiation | various. |
| Thermometer and frame, deep sea | Negretti & Zambra. |
| Thermometer, self-recording | Hipp. |
| Thermometer, self-recording | Hough. |
| Thermometer, self-recording | Wild. |
| Thermometer, self-recording, photographic | Beck. |

| Kind of instrument, etc. | Maker. |
|---|---|
| Thermometer, metallic | |
| Telegraph instruments: | |
| Annunciator, telegraph | |
| Arrester, lightning | |
| Arrester, lightning, cable | |
| Apparatus for electric light | |
| Boards, switch | |
| Box, magnetic, call | |
| Button, push | |
| Keys, telegraph | |
| Field telegraph machine | |
| Siemen knapsack | |
| Siemen transport case | |
| Siemen cable drum | |
| Magneto-electric machine | |
| Resistance coil | |
| Relay | |
| Relay, pocket | |
| Repeater | |
| Sabine discharger | |
| Switch, telegraph | |
| Switch, telephone | |
| Sounder | |
| Sounder, box | |
| Shunts, galvanometer | |
| Telephone | |
| Transmitter | |
| Wheatstone bridge | |
| Batteries: | |
| Callaud | |
| Eagle, round | |
| Eagle, square | |

| Kind of instrument, etc. | Maker. |
|---|---|
| Batteries: | |
| Daniells | |
| Le Clanche | |
| Gravity | |
| Telegraph tools: | |
| Apparatus, soldering | |
| Bars, crow | |
| Bags, tool | |
| Belt for climber | |
| Block and tackle, set | |
| Boots, iron | |
| Boxes, canvas | |
| Boxes, cable | |
| Clamps, splicing | |
| Climbers and straps | |
| Drivers, plug | |
| Furnace, soldering | |
| Gauges, wire | |
| Iron, soldering | |
| Battery knife | |
| Pikes | |
| Plates, ground | |
| Pliers, cutting | |
| Pulleys | |
| Pulleys and tackle with vises | |
| Reels, wire | |
| Reels, cable | |
| Shovel, long handle | |
| Shovel, spoon | |
| Shovel, digging | |
| Scrapers, battery | |
| Syringe, battery | |
| Tools, soldering | |
| Vises, hand | |
| Wrench, splicing | |
| Wrench, monkey | |
| Weather case | |

# LIST OF SIGNAL SERVICE STATIONS IN OPERATION JUNE 30, 1884.

STATIONS OF THE FIRST ORDER.

*Making a continuous record by means of self-registering instruments.*

Washington, D. C. §

STATIONS OF THE SECOND ORDER.

*Taking six observations daily, reporting three times a day by telegraph, and monthly by mail.*

Bismarck, Dak. ‡
Buffalo, N. Y. †* § ↔
Cincinnati, Ohio. ‡ § ↔
New York City. †* §
Pittsburg, Pa. ‡ §
Saint Louis, Mo. ‡ § ↔
Boston, Mass. †* §
Chicago, Ills. †* § ↔
Kitty Hawk, N. C. *
Philadelphia, Pa. §
Prescott, Ariz.
San Francisco, Cal. † §

STATIONS OF THE SECOND ORDER.

*Taking five observations daily, reporting three times a day by telegraph, and monthly by mail.*

Albany, N. Y. § ↔
Atlanta, Ga. ‖
Augusta, Ga. † ‡ ‖
Barnegat City, N. J. *
Cairo, Ill. ‡
Cedar Keys, Fla. †* ‖
Charlotte, N. C. ‖
Cheyenne, Wyo.
Cleveland, Ohio. †*
Concho, Fort, Tex.
Davenport, Iowa. ‡
Delaware Breakwater, Del. †*
Des Moines, Iowa. §
Dodge City, Kans.
El Paso, Tex.
Escanaba, Mich. †*
Galveston, Tex. †* ‖
Hatteras, N. C. *
Indianapolis, Ind.
Jacksonville, Fla. †*
Key West, Fla. †*
La Crosse, Wis. ‡
Little Rock, Ark. ‡ ‖ ↔
Louisville, Ky. ‡ ↔
Mackinaw City, Mich. †*
Marquette, Mich. †*
Milwaukee, Wis. †*
Montgomery, Ala. ‖
Alpena, Mich. †*
Atlantic City, N. J. †*
Baltimore, Md. †*.
Block Island, R. I. †*
Cape Henry, Va. *
Charleston, S. C. †* ‖
Chattanooga, Tenn. ‡ ↔
Chincoteague, Va. †*
Columbus, Ohio.
Custer, Fort, Mont.
Deadwood, Dak.
Denver, Colo.
Detroit, Mich †* §
Eastport, Me. †*
Erie, Pa. *
Fort Smith, Ark. ‡ ‖
Grand Haven, Mich. †*
Huron, Dak.
Indianola, Tex. †*
Keokuk, Iowa. ‡
Knoxville, Tenn. ‡
Leavenworth, Kan. ‡ §
Los Angeles, Cal.
Lynchburg, Va.
Macon, Fort, N. C. *
Memphis, Tenn. ‡ ‖
Mobile, Ala. †* ‖
Moorhead, Minn.

Mount Washington, N. H.
New Haven, Conn. †*
Norfolk, Va. †*
Olympia, Wash. T.
Oswego, N. Y. *
Pensacola, Fla. †*
Portland, Me. †*
Red Bluff, Cal. ‡
Rochester, N. Y.
Sacramento, Cal. ‡
Saint Vincent, Minn.
San Diego, Cal.
Sandy Hook, N. J. †*
Savannah, Ga. †*‖
Smithville, N. C. †*
Toledo, Ohio. †*
West Las Animas, Colo.
Yankton, Dak. ‡
Nashville, Tenn. ‡§‖ ↔
New Orleans, La. ‡*‖
North Platte, Nebr.
Omaha, Nebr. ‡
Palestine, Tex. ‖
Port Huron, Mich. *
Portland, Oreg. ‡†
Rio Grande City, Tex.
Roseburg, Oreg.
Saint Paul, Minn. ‡
Salt Lake City, Utah.
Sandusky, Ohio. †*
Sanford, Fla.
Shreveport, La. ‡‖
Springfield, Ill.
Vicksburg, Miss. ‡‖
Wilmington, N. C. †*‖
Yuma, Ariz. ‡

*Taking five observations daily, making report once a day by telegraph, and full reports monthly by mail.*

Dubuque, Iowa. ‡

*Taking five observations daily and reporting monthly by mail.*

Boisé City, Idaho.
Lady Franklin Bay, Grinnell Land.
New London, Conn. †*
Sitka, Alaska.
Chimo, Fort, (Ungava Bay,) Labrador.
Myer, Fort, Va. ¶
Pike's Peak, Col.

*Taking three observations daily, reporting three times a day by telegraph, and monthly by mail.*

Apache, Fort, Ariz.
Bennett, Fort, Dak.
Brownsville, Tex.
Canby, Fort, Wash. T. †
Duluth, Minn. †*
Helena, Mont.
Maginnis, Fort, Mont.
Shaw, Fort, Mont.
Spokane Falls, Wash. T.
Tatoosh Island, Wash. T.
Assinaboine, Fort, Mont.
Benton, Fort, Mont. ‡
Buford, Fort, Dak.
Cape Mendocino, Cal.
Elliott, Fort, Tex.
Lewiston, Idaho.
Poplar River, Mont.
Sill, Fort, Ind. T.
Stockton, Fort, Tex.
Totten, Fort, Dak.

*Taking three observations daily and reporting monthly by mail.*

Alexander, Fort, Alaska.
Cape May, N. J.*
Dayton, Wash. T.
Saint Michael's, Fort, Alaska.
Thomas, Camp, Ariz.
Behring's Island, Behring Sea.
Davis, Fort, Tex.
Grant, Fort, Ariz.
Unalashka, Alaska.

STATIONS OF THE THIRD ORDER.

*Taking two observations daily (at 3 p. m. and 11 p. m., Washington time), and reporting monthly by mail.*

Anvik, Alaska.
Chilkaht, Alaska.
Hoochnahoo, Alaska.
Atka, Alaska.
Cordova Bay, Alaska.
Hoonyah, Alaska.

Kenai, Alaska.
Petropaulovski, Kamtchatka.
Tananah, Alaska.
Wrangell, Fort, Alaska.
Koskokvim, Alaska.
Port Etches, Alaska.
Tcha-tow-klin, Alaska.
Yakutat Bay, Alaska.

*Taking one observation daily (at the hour of sunset), and reporting monthly by mail..*

Apache Pass, Ariz.
Astoria, Oreg.
Bridger, Fort, Wyo.
Cœur d'Alene, Fort, Idaho.
Durango, Colo.
Golovin Bay, Alaska.
Henrietta, Tex.
Klamath, Fort, Oreg.
Linkville, Oreg.
Marfa, Tex.
McDowell, Fort, Ariz.
Mission, Alaska.
Narragansett Pier, R. I.
New River Inlet, N. C.
Nulato, Alaska.
Phœnix, Ariz.
Port Angeles, Wash. T.
Reliance, Fort, Alaska.
Saint George's Island, Alaska.
San Carlos Agency, Ariz.
Sisseton, Fort, Dak.
Spokane, Fort, Wash. T.
Sully, Fort, Dak.
Thatcher's Island, Mass.*
Ugashik, Alaska.
Wash Woods, N. C.
Webster, Dak.
Ashland, Oreg.
Bidwell, Fort, Cal.
Cantonment, Ind. T.
Craig, Fort, N. Mex.
Florida Station, N, Mex.
Harrisburg (or Juneau City), Alaska.
Lakeview, Oreg.
Little Egg Harbor, N. J.*
Maricopa, Ariz.
Meade, Fort, Dak.
Montrose, Colo.
Neah Bay, Wash. T.
Nuduckayet, Alaska.
Ocean City, Md.
Point Judith, R. I.*
Pysht, Wash. T.
Reno, Fort, Ind. T.
San Marcial, N. Mex.
Scott's Hill, N. C.
Stanton, Fort, N. Mex.
Supply, Fort, Ind. T.
Thornburg, Fort, Utah.
Verde, Fort, Ariz.
Watrous, N. Mex.
Willcox, Ariz.
Wickenburg, Ariz.
Yates, Fort, Dak.

REPAIR STATIONS.

*Stations on the United States military telegraph lines at which no observations are taken.*

Ash Fork, Ariz.
Carter, Wyo.
Glendive, Mont.
Larimore, Dak.
Crescent Bay, Wash. T.
Hoko, Wash. T.
Terry's Landing, Mont.

SPECIAL PRINTING STATIONS.

Bangor, Me.
Logansport, Ind.
Burlington, Iowa.

DISPLAY STATIONS.

Ahnapee, Wis.
Bass River Light, Mass.
Bay City, Mich.
Bristol, R. I.
Cape Vincent, N. Y.
Charlotte, N. Y.
Corpus Christi, Tex.
East Tawas, Mich.
Fall River, Mass.
Ashtabula, Ohio.
Bath, Me.
Boothbay, Me.
Brunswick, Ga.
Charlevoix, Mich.
City Island, N. Y.
Dunkirk, N. Y.
Elk Rapids, Mich.
Fort George Island, Fla.

Fire Island, N. Y.
Frankfort, Mich.
Green Bay, Wis.
Hyannis, Mass.
Kewaunee, Wis.
Mackinac, Fort, Mich.
Manitowoc, Wis.
Menominee, Mich.
Montague, Mich.
Muskegon, Mich.
Newburyport, Mass.
Newport, R. I.
Northport, Mich.
Petoskey, Mich.
Portsmouth, N. H.
Racine, Wis.
Saint Augustine, Fla.
Saint Joseph, Mich.
Sand Key Light, Fla.
Southeast Light, Block Island, R. I.
South Haven, Mich.
Stonington, Conn.
Tybee Island, Ga.
Gloucester, Mass.
Highland Light, Mass
Kenosha, Wis.
Ludington, Mich.
Manistee, Mich.
Marblehead, Mass.
Monroe, Fort, Va.
Morgan, Fort, Ala.
New Bedford, Mass.
New Haven Light, Conn.
North Fair Haven, N. Y.
Pentwater, Mich.
Port Royal, S. C.
Provincetown, Mass.
Rockland, Me.
Saint Ignace, Mich.
Sand Beach, Mich.
Sheboygan, Wis.
Southwest Harbor, Me.
Sturgeon Bay, Wis.
Traverse City, Mich.
Wood's Holl, Mass.

SPECIAL RIVER STATIONS.

*Observations of the stage of water in the river are taken at 2 p. m. (Washington time), daily*

Albany, Oreg.
Brownsville, Pa.
Charleston, Tenn.
Colusa, Cal.
Decatur, Ala.
Evansville, Ind.
Freeport, Pa.
Hermann, Mo.
Johnsonville, Tenn.
Kingston, Tenn.
Le Claire, Iowa.
Mahoning, Pa.
Marysville, Cal.
Mount Carmel, Ill.
New Geneva, Pa.
Oroville, Cal.
Peoria, Ill.
Plattsmouth, Nebr.
Saint Joseph, Mo.
Strawberry Plains, Tenn.
Boonville, Mo.
Brunswick, Mo.
Clinton, Tenn.
Confluence, Pa.
Eugene City, Oreg.
Folsom City, Cal.
Jefferson City, Mo.
Kansas City, Mo.
Leadvale, Tenn.
Lexington, Mo.
Loudon, Tenn.
Marietta, Ohio.
Muscatine, Iowa.
Oil City, Pa.
Paducah, Ky.
Rockwood, Tenn.
Saltsburg, Pa.
Umatilla, Oreg.
Wheeling, W. Va.
Warsaw, Ill.

SPECIAL COTTON-REGION STATIONS AND CENTRES.

*One observation made daily at 5 p. m. (central time).*

Wilmington, North Carolina (centre).

Florence, S. C.
Lumberton, N. C.
Raleigh. N. C.
Wadesborough, N. C.
Cheraw, S. C.
Goldsborough, N. C.
New Berne, N. C.
Salisbury, N. C.
Weldon, N. C.

Charleston, South Carolina (centre).

Branchville, S. C.
Hardeeville, S. C.
Jacksonborough, S. C.
Kingstree, S. C.
Saint George's, S. C.
Saint Matthew's, S. C.
Yemassee, S. C.

Augusta, Georgia (centre).

Allendale, S. C.
Athens, Ga.
Batesburg, S. C.
Blackville, S. C.
Camak, Ga.
Chester, S. C.
Columbia, S. C.
Greenwood, S. C.
Union Point, Ga.
Washington, Ga.
Waynesborough, Ga.

Savannah, Georgia (centre).

Albany, Ga.
Allapaha, Ga.
Bainbridge, Ga.
Fernandina, Fla
Eastman, Ga.
Jessup, Ga.
Fort Gaines, Ga.
Millen, Ga.
Live Oak, Fla.
Smithville, Ga.
Quitman, Ga.
Waldo, Fla.
Thomasville, Ga.
Way Cross, Ga.

Atlanta, Georgia (centre).

Anderson, S. C.
Cartersville, Ga.
Columbus, Ga,
Dalton, Ga.
Gainesville, Ga.
Greenville, S. C.
Griffin, Ga.
Macon, Ga.
Newnan, Ga.
Spartanburg, S. C
Toccoa, Ga.
West Point, Ga.

Montgomery, Alabama (centre).

Birmingham, Ala.
Calera, Ala.
Eufaula, Ala.
Fort Deposit, Ala.
Greenville, Ala.
Marion, Ala.
Opelika, Ala.
Pine Apple, Ala.
Selma, Ala.

Mobile, Alabama (centre).

Aberdeen, Miss.
Columbus, Miss.
Evergreen, Ala.
Livingston, Ala.
Macon, Miss.
Meridian, Miss.
Okolona, Miss.
Waynesborough, Miss.

New Orleans, Louisiana (centre).

Alexandria, La.
Amité City, La.
Brookhaven, Miss.
Cheneyville, La.
Coushatta Chute, La.
Hazelhurst, Miss.
Lafayette, La.
Minden, La.
Natchez, Miss.
Natchitoches, La.
Opelousas, La.
Whiteville, La.

Galveston, Texas (centre).

Austin, Tex.
Beaumont, Tex.
Belton, Tex.
Columbia, Tex.
Corsicana, Tex.
Cuero, Tex.
Dallas, Tex.
Hearne, Tex.
Hempstead, Tex.
Houston, Tex.

Huntsville, Tex.
Luling, Tex.
Sour Lake, Tex.
Waco, Tex.
Weimar, Tex.
Longview, Tex.
Orange, Tex.
San Antonio, Tex.
Tyler, Tex.
Weatherford, Tex.

Vicksburg, Mississippi (centre).

Edwards, Miss.
Lake, Miss.
Jackson, Miss.
Monroe, La.‡

Little Rock, Arkansas (centre).

Arkansas City, Ark.
Devall's Bluff, Ark.
Helena, Ark.‡
Madison, Ark.
Malvern, Ark.
Newport, Ark.
Pine Bluff, Ark.
Russellville, Ark.
Brinkley, Ark.
Kensett, Ark.
Magnolia, Ark.
Monticello, Ark.
Paris, Tex.
Prescott, Ark.
Texarkana, Ark.

Memphis, Tennessee (centre).

Batesville, Miss.
Bolivar, Tenn.
Brownsville, Tenn.
Covington, Tenn.
Dyersburg, Tenn.
Grenada, Miss.
Holly Springs, Miss.
Paris, Tenn.
Tuscumbia, Ala.
Corinth, Miss.
Decatur, Ala.
Grand Junction, Tenn.
Hernando, Miss.
Milan, Tenn.
Oxford, Miss.
Scottsborough, Ala.
Withe, Tenn.

* Displays cautionary signals.

† Takes observations of temperature of the water in river or harbor at 2 p. m (Washington time), daily.

‡ Takes observations of the stage of water in the river at 2 p. m. (Washington time), daily.

§ Prints Farmers' Bulletin.

‖ Takes cotton-region observations at 5 p. m. (central time), daily.

¶ Fort Myer, Va., is maintained as a 1st class station whenever a class is under instruction; at other times as a 3d class station.

↔ Displays cold-wave signal.

## RECAPITULATION.

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|---|---|
| Stations taking six (6) observations daily, reporting three times a day by telegraph and monthly by mail | 13 |
| Stations taking five (5) observations daily, reporting three times a day by telegraph and monthly by mail | 92 |
| Stations taking five (5) observations daily, making report once a day by telegraph and monthly by mail | 1 |
| Stations taking five (5) observations daily and reporting monthly by mail | 7 |
| Stations taking three (3) observations daily, reporting three times a day by telegraph, and monthly by mail | 20 |
| Stations taking three (3) observations daily and reporting monthly by mail | 9 |
| Stations at which two (2) observations are taken daily | 14 |
| Stations at which one (1) observation is taken daily | 54 |

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| Special printing stations | 3 |
| Display stations | 64 |
| Special river stations | 42 |
| Special cotton-region stations | 138 |
| Stations of observation at which the stage of water in the river is observed daily | 29 |
| Stations of observation at which the temperature of the water in the river or harbor is observed daily | 41 |
| Stations of observation at which cotton-region observations are taken daily at 5 p. m | 18 |
| Stations of observation which display the cautionary signal | 50 |
| Stations of observation which display the cold-wave signal | 10 |
| Stations of observation at which the "Farmers' Bulletin" is printed | 15 |
| Repair stations on the United States military telegraph lines, at which no observations are taken | 7 |
| Total number of stations | 464 |
| Total number of stations at which cotton-region observations are taken | 156 |
| Total number of stations displaying cautionary signals | 114 |
| Total number of river stations | 71 |
| Total number of printing stations | 18 |